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Applicant: **XEROX CORPORATION**  
Xerox Square  
Rochester New York 14644(US)

Inventor: **Drake, Donald J.**

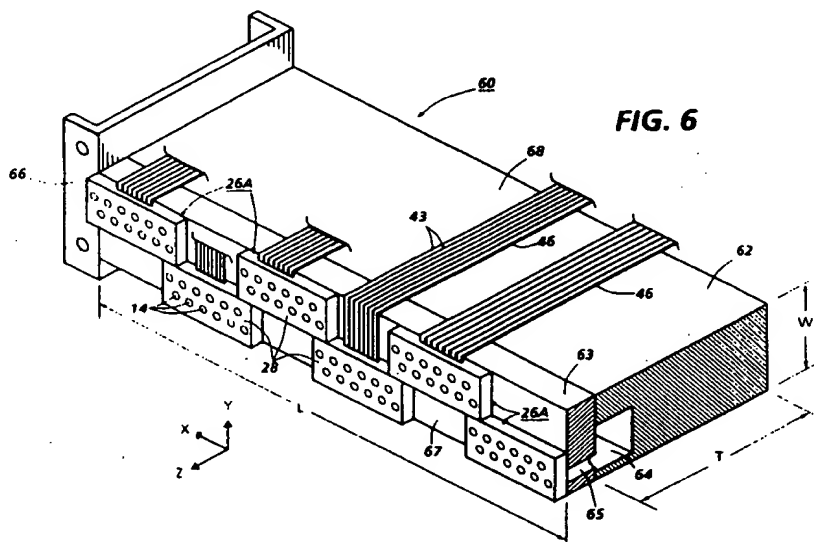
480 French Road  
Rochester, New York, 14618(US)

Representative: **Hill, Cecilia Ann et al**  
Rank Xerox Patent Department Albion  
House, 55 New Oxford Street  
London WC1A 1BS(GB)

**Pagewidth thermal ink jet printhead.**

A pagewidth thermal ink jet printhead for an ink jet printer is disclosed. The printhead is of the type assembled from fully functional roofshooter type printhead subunits (26A) fixedly mounted on the surface of one side (67) of a structural bar (62). A passageway (64) is formed adjacent the bar side surface containing the printhead subunits with openings (65) provided between the passageway and the ink inlets of the printhead subunits, mounted thereon so that ink supplied to the passageway in the bar will

maintain the individual subunits full of ink. The size of the printing zone for color printing is minimized because the roofshooter printhead subunits are mounted on one edge of the structural bar and may be stacked one on top of the other without need to provide space for the printhead subunits and/or ink supply lines. In addition, the structural bar thickness (T) enables the bar to be massive enough to prevent warping because of printhead operating temperatures.



This invention relates to thermal ink jet printing on demand, and more particularly to pagewidth thermal ink jet printheads.

There are two general configurations for thermal, drop-on-demand, ink jet printheads. In one configuration, droplets are propelled from nozzles in a direction parallel to the flow of ink in ink channels and parallel to the surface of the bubble-generating heating elements of the printhead, such as, for example, the printhead configuration disclosed in U.S. Reissue Patent RE 32,572 to Hawkins et al. and schematically shown in Figure 1. This configuration is sometimes referred to as an edge or side shooter. The other thermal ink jet configuration propels droplets from nozzles in a direction normal to the surface of the bubble-generating heating elements such as, for example, the printhead disclosed in U.S. Patent number 4,568,953 to Aoki et al. This latter configuration is sometimes referred to as a roofshooter and is schematically illustrated in Figure 2. It can be seen that a fundamental difference lies in the direction of droplet ejection. The sideshooter configuration ejects droplets in the plane of the substrate having the heating elements, while the roofshooter ejects droplets out of the plane of the substrate having the heating elements and in a direction normal thereto.

U.S. Reissue Patent number RE 32,572 to Hawkins et al. discloses a sideshooter configuration for a thermal ink jet printhead and several fabricating processes therefor. Each printhead is composed of two parts aligned and bonded together. One part is a substantially flat substrate which contains on the surface thereof a linear array of heating elements and addressing electrodes, and the second part is a substrate having at least one recess anisotropically etched therein to serve as an ink supply manifold when the two parts are bonded together. A linear array of parallel grooves is also formed in the second part so that one end of each of the grooves communicates with the manifold recess and the other end is open for use as an ink droplet expelling nozzle. Many printheads can be made simultaneously by producing a plurality of sets of heating element arrays with their addressing electrodes on a silicon wafer. A corresponding plurality of sets of channels and associated manifolds are produced in a second silicon wafer. The two wafers are aligned and bonded together and then diced into many separate printheads. The printheads may be used in carriage-type printers for printing swaths of information and then stepping the recording medium a distance of one swath and continuing to print adjacent swaths of information until a full page of information is printed. Alternatively, the printheads may be considered as subunits of a pagewidth printhead and arranged on a

structural image bar for pagewidth printing. In pagewidth printing, the printheads may be assembled by abutting a plurality of the printhead subunits end-to-end on the image bar or staggering them on two separate image bars or on opposite sides of the same image bar.

U.S. Patent number 4,568,953 to Aoki et al. discloses a thermal ink jet printhead in which the droplets are ejected on demand through nozzles aligned above and parallel to the heating elements, so that the droplet trajectories are normal to the heating elements. In order to prevent nozzle clogging, the ink is circulated through the printhead and internal passageways having cross-sectional flow areas larger than the nozzles. This enables particulate matter larger than the nozzles to pass and be swept away by the circulating ink entering and leaving the printhead through inlet and outlet tubes.

U.S. Patent number 4,789,425 to Drake et al. discloses a roofshooter-type thermal ink jet printhead, wherein each printhead comprises a silicon heater plate and a fluid directing structural member. The heater plate has a linear array of heating elements, associated addressing electrodes, and an elongated ink-filled hole parallel with the heating element array. The structural member contains at least one recessed cavity, a plurality of nozzles, and a plurality of parallel walls within the recessed cavity which define individual ink channels for directing the ink to the nozzles. The recessed cavity and fill hole are in communication with each other and form the ink reservoir within the printhead. The ink holding capacity of the fill hole is larger than that of the recessed cavity. The fill hole is precisely formed and positioned within the heater plate by anisotropic etching. The structural member may be fabricated either from two layers of photoresist, a two-stage flat nickel electroform, or a single photoresist layer and a single stage flat nickel electroform.

U.S. Patent number 4,829,324 to Drake et al. discloses a large array ink jet printhead having two basic parts, one containing an array of heating elements and addressing electrodes on the surface thereof, and the other containing the liquid ink handling system. At least the part containing the ink handling system is silicon and is assembled from generally identical subunits aligned and bonded side-by-side on the part surface having the heating element array. In one embodiment a plurality of channel plate subunits is anisotropically etched in a silicon wafer and a plurality of heating element subunits is formed on another silicon wafer. The heating element wafer is also anisotropically etched with elongated slots. The wafers are aligned and bonded together, then diced into complete printhead subunits which have abutting side surfaces that are {111} planes for accurate side-

by-side assembly.

U.S. Patent number 4,851,371 to Fisher et al. and U.S. Patent number 4,935,750 to Hawkins disclose a cost effective method of fabricating a large array or pagewidth silicon device having high resolution. The pagewidth device is assembled by abutting silicon device subunits such as image sensors or thermal ink jet printheads. For printheads, the subunits are fully functional small printheads comprising an ink flow directing channel plate and a heating element plate which are bonded together. A plurality of individual printhead subunits is obtained by dicing aligned and bonded channel wafers and heating element wafers. The abutting edges of the printhead subunits are diced in such a manner that the resulting kerfs have vertical to inwardly directed sides which enable high tolerance linear abutment of adjacent subunits. U.S. Patent 4,935,750 discloses how a pagewidth printhead may be further stabilized and strengthened by assembly of printhead subunits on a flat structural member. Assembly of the pagewidth printhead is complete when an elongated hollow conduit means having a plurality of outlets is mounted over the subunits with each outlet aligned with a one of the inlets of the printhead subunits. Gaskets are sealed to the outlets of the conduit means by, for example, an adhesive earlier screened onto the gasket. The gasket sealingly surrounds the printhead subunit inlet and outlets of the conduit means and prevents the ink supplied to the printhead subunits via the conduit means from leaking at the interface therebetween.

U.S. Patent number 4,985,710 to Drake et al. discloses a "roofshooter" pagewidth printhead for use in a thermal ink jet printing device fabricated from a plurality of subunits, each being produced by bonding a heater substrate, having an architecture including an array of heater elements and an etched ink feed slot, to a secondary substrate having a series of spaced feed hole openings to form a combined substrate in which the series of spaced feed hole openings communicates with the ink feed slot, and dicing the combined substrates through the ink feed slot to form a subunit. An array of butted subunits having a length equal to one pagewidth is formed by butting one of the subunits against an adjacent subunit. The array of butted subunits is bonded to a pagewidth support substrate. The secondary substrate provides an integral support structure for maintaining the alignment of the heater plate which, if diced through the feed hole without the secondary substrate, would separate into individual pieces, thereby complicating the alignment and assembly process.

It is the object of the present invention to provide an improved pagewidth thermal ink jet printhead.

According to the present invention, a pagewidth thermal ink jet printhead for an ink jet printer is assembled from fully functional roofshooter-type printhead subunits which are fixedly mounted on the surface of one side of a structural bar. A passageway is formed in the bar and adjacent the bar side surface containing the printhead subunits with openings provided between the passageway and the ink inlets of the printhead subunits mounted thereon, so that ink supplied to the passageway in the bar will maintain the individual subunits full of ink.

For color printing, wherein a plurality of pagewidth printheads in accordance with the invention are used, the size of the printing zone can be minimized because the roofshooter printhead subunits are mounted on one edge of the structural bar and may be stacked one on top of the other without need to provide space for the printhead subunits and/or ink supply manifolds or lines. Advantageously, the structural bar thickness enables the bar to be massive enough to prevent warping because of printhead operating temperatures.

The present invention further provides a pagewidth, thermal ink jet printhead for use in an ink jet printer and of type assembled from a plurality of fully functional printhead subunits, each subunit having an array of droplet emitting nozzles, so that when the printhead is fixedly mounted in the printer, the nozzles confront a path through which a recording medium is moved to define a printing zone having the length of at least the width of a page, the printhead comprising:

a structural bar having an edge surface between end surfaces, a length at least equal to that of the printing zone, and a cross-sectional area defined by a predetermined width and thickness of the bar, so that the edge surface of the bar has a surface area defined by the bar length and width, the edge surface confronting the recording medium path when it is mounted in the printer;

a passageway being provided within the bar and being adjacently spaced a predetermined distance from the bar edge surface;

a plurality of openings penetrating the adjacent edge surface and communicating with the passageway;

a plurality of roofshooter type printhead subunits being mounted on the bar edge surface, each subunit having an ink inlet aligned with a respective one of the openings in said bar edge surface and having a plurality of heating elements, each of which is aligned with a respective one of the subunit nozzles for ejection of ink droplets in a direction normal to the heating elements and towards the recording medium path;

means for fixedly mounting the structural bar within the printer, so that the subunits confront the

recording medium and are spaced predetermined distance therefrom;

means for providing ink to the bar passageway from an ink supply; and

means for selectively applying electrical signals to the heating elements of the subunits, the signals representing digitized data for the drop-on-demand ejection of ink droplets by the temporary vaporization of ink as a result of the application of the electrical signals, whereby the structural bar thickness is sufficient to provide enough mass for the bar to prevent its warping as a result of the operating temperature of the pagewidth printhead.

By way of example only, embodiments of the invention will be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross-sectional view of a typical prior art sideshooter-type thermal ink jet printhead.

Figure 2 is a schematic cross-sectional view of a typical prior art roofshooter-type thermal ink jet printhead.

Figure 3A is a front view of a typical prior art pagewidth printhead formed by staggered sideshooter printhead subunits on two separate structural bars.

Figure 3B is a front view of a typical prior art pagewidth printhead formed by sideshooter printhead subunits in a staggered array on opposite sides of a single structural bar.

Figure 4 is a partial isometric view of the prior art pagewidth printhead shown in Figure 3A.

Figure 5 is an enlarged partially shown front view of a typical prior art pagewidth printhead formed from the abutment of smaller sideshooter printhead subunits produced by the abutment of the subunits on a single structural bar.

Figure 6 is a partially shown isometric view of a pagewidth printhead in accordance with the present invention, formed by staggered roofshooter printhead subunits on a single structural bar.

Figure 7 schematically shows the warpage of the structural bar used in Figure 3A.

Figure 8 is a front view of a multi-color pagewidth thermal ink jet printhead constructed from a plurality of the printheads shown in Figure 6.

Figure 9 is a front view of a multi-color pagewidth printhead formed from a plurality of pagewidth printheads shown in Figure 5.

In Figure 1, a typical sideshooter or edgeshooter-type thermal ink jet printhead 10 is schematically shown in cross-sectional view with the capillary-filled channel 12 terminating with a nozzle 14 at the edge or side 13 of the printhead. The other end of the channel communicates with

reservoir 17 which is anisotropically etched in silicon channel plate 11. Concurrently etched with the reservoir, or in a separate etching step, the channels 12 are etched in channel plate 11, as disclosed in U.S. Reissue 32,572 to Hawkins et al. and U.S. Patent 4,935,750 to Hawkins. Heater plate 16 contains the heating elements 20 and passivated addressing electrodes 21 and common return 22 (passivation layer not shown) over which thick film layer 23 is laminated and patterned to provide individual recesses over each heating element to form pits 24. The reservoirs 17 are formed by through etches which provide inlet 25 for entrance of the ink 32 through filter 18 which is placed over the inlet. As is well known in the art, an electric pulse applied to the heating element momentarily vaporizes the ink and forms bubble 19 which expels droplet 15 from nozzle 14. The ink in the channels are supplied by capillary action from reservoir 17 as shown by arrow 31.

A typical roofshooter-type thermal ink jet printhead is shown in Figure 2. In this configuration, the silicon heater plate 27 has a reservoir or feed slot 30 etched therethrough. The inlet 25 is covered by filter 18. An array of heating elements 20 are patterned on heater plate surface 33 near the open bottom of reservoir 30. The heating elements are selectively addressed via passivated addressing electrodes 21 and common return 22 (passivated layer not shown). A flow directing layer 29 is patterned to form flow paths for the ink from the reservoir to a location above the heating elements as shown by arrow 31. A nozzle plate 28 containing nozzles 14 is aligned and bonded to flow directing layer 29 so that the nozzles are directly above the heating elements. Electric signals applied to the heating element temporarily vaporize the ink and form droplet ejecting bubbles 19 which eject droplets 15 in a direction normal to the heating element.

Figure 3A depicts one prior art embodiment of a pagewidth thermal ink jet printhead wherein the fully functional sideshooter printhead subunits are mounted on structural bars 38 in an equally spaced manner. The structural bars with sideshooter printheads 10 similar to those shown in Figure 1 are fastened together by bar connectors 39 having mounting flanges 40. The printheads on each structural bar are supplied with ink from manifold 37 which has openings (not shown) aligned and sealed with the inlets of the printhead subunits. The bar connectors provide the appropriate spacing between bars to provide clearance for the ink manifolds as well as the printhead subunits. The structural bars and connectors are fixedly attached to each other by, for example, bolts 41. The printhead subunits on one of the structural bars are offset from the printhead subunits of the other structural

bar to provide pagewidth coverage by the droplets ejected from the nozzles from all of the printhead subunits. To aid in the understanding of the orientation of the pagewidth printhead, the X, Y and Z coordinates are shown in Figure 3A, with the Z direction being the direction the droplets travel from the printhead nozzles to the recording medium. The X direction is in a plane parallel to the recording medium, and the Y direction indicates the direction of movement of the recording medium past the pagewidth printhead. Thus, in this view, the droplets would travel from the nozzles at the plane of the paper in a direction perpendicular therefrom towards the viewer. An alternate prior art pagewidth printhead utilizing sideshooter printhead subunits is shown in Figure 3B, where a single structural bar 38 is used with mounting bar flanges 40 on either edge and with the sideshooter thermal ink jet printhead subunits mounted in a staggered fashion on opposite sides thereof. The printhead subunits on each side of the bar have an ink manifold 37 with openings (not shown) aligned and sealed with the inlets of the printhead subunits to prevent ink leakage therefrom.

Referring to Figure 4, a portion of the pagewidth printhead of Figure 3A is shown in isometric view with the ink supplying manifolds 37 partially shown in dashed line. The X, Y and Z coordinates show the orientation of the printhead subunits 10 relative to the recording medium (not shown). In this figure, the subunits are shown with the signal supplying lines 43 attached to the printhead electrodes 21 via wire bonds 42.

An alternate embodiment of a prior art pagewidth printhead is shown in Figure 5. In this configuration, an enlarged partially shown front elevation view of a pagewidth ink jet printhead 48 is shown of the type that is assembled from sideshooter printhead subunits 10A abutted end-to-end. The length is the width of a page or about 8.5 inches (21.6 cm) to 11 inches (28 cm) and the front face height W of the printhead and ink supplying manifold is about 0.50 to 1.0 inch (1.25 to 2.5 cm). Schematically illustrated heating elements 20 are shown in each channel 12 through nozzles 14. In this pagewidth embodiment, a very small v-groove 59 is optionally anisotropically etched in the surface of the heater plate wafer parallel to and on opposing sides of each set of heating elements, so that the slightly slanted dicing used to produce slanted walls 49 do not cut through the surface 50 containing the heating elements and supporting electrodes and circuitry (not shown). This eliminates all micro-cracking because the dicing blade only cuts outside of the {111} plane of the small v-groove 59. The confronting walls 49 of the heater plate 16A were preferably done with a slightly slanted dicing blade to enable the close tolerance

abutting of the printhead subunits 10A. The oppositely sloping walls 49 produce gaps 53 because the bottom surface of the heater plates 16A are smaller than the top surfaces 50 when the dicing cut is made by slanted dicing blades which are slanted in equal but opposite directions. To strengthen the pagewidth printhead 48, the gaps 53 between the heater plates 16A specifically generated by slanted kerfs that produce sloping or slanted walls 49 may be optionally filled (not shown) with a flowable epoxy or other suitable adhesive. The pagewidth printhead 48 may be further stabilized and strengthened by assembly of the printhead subunits 10A on a flat structural member 38. Assembly of the pagewidth printhead 48 is complete when an elongated hollow manifold 37 having outlets 34, each aligned with inlets 25 of the printhead subunits 10A. Gaskets 35 are sealed to the manifold 37 by a suitable adhesive. The gasket sealingly surrounds the printhead subunit inlets and outlets of the manifold and prevents the ink supplied to the printhead subunits via the manifold from leaking at the interface therebetween. For a more detailed description of this prior art pagewidth printhead, refer to U.S. Patent 4,935,750 to Hawkins. The X, Y, Z coordinates are also shown for this figure; thus, the droplets are ejected from the plane of the sheet containing Figure 5 and in a direction normal thereto and in a direction towards the viewer.

Referring to Figure 6, a pagewidth thermal ink jet printhead 60 in accordance with the present invention is shown, using roofshooter-type printhead subunits 26A. The printhead subunits, each similar in construction to that depicted in Figure 2, are mounted on edge 67 of structural bar 62 in two rows in an offset staggered manner. Each printhead subunit inlet is aligned with openings 65 in bar 62 which place the printhead subunit reservoirs 30 (see Figure 2) into communication with ink supply passageway 64 formed in the bar adjacent the bar edge 67. Flexible cables 46 with signal lines 43 therein are mounted on surface 68 of the structural bar 62 and connected to electrodes 21 (Figure 2) of the printhead subunits by means such as wire bonding (not shown). Mounting flanges 66 are attached to each end of the structural bar to provide means for mounting the pagewidth printhead in a printer. Each printhead subunit 26A contains two rows of nozzles offset from one another and a cross-sectional view through one nozzle is depicted in Figure 2. For ease in providing a passageway for the ink, the structural bar comprises two parts, the main part has a groove 64 milled through one edge thereof and the part is cover 63 which is bonded over the groove and which contains openings 65 therethrough. The length of the pagewidth bar is depicted by dimen-

sion L which is at least the distance across the width of the recording medium to be printed in the printer printing zone. The width of the structural bar is dimensioned to accommodate two printhead subunits and is depicted by the dimension W. A thickness or depth of the bar is shown as dimension T. An external ink supply (not shown) is located in a spaced location from the pagewidth printhead and provides ink to the passageway 64 in the structural bar by hoses (not shown). Ends of the hose are sealingly attached to the passageway 64 by well known coupling means.

As already mentioned, there are two fundamental printhead architectures for thermal ink jet printheads. One is the edgeshooter or sideshooter printhead shown in Figure 1. The other is the roofshooter printhead shown in Figure 2. It can be seen that a fundamental difference lies in the direction of drop ejection. In the sideshooter configuration, droplets are ejected in a plane parallel to the heating element surfaces on the heater plate while in the roofshooter configuration, the droplets are ejected in a direction normal to the surface of the heating element.

In the construction of a pagewidth array of thermal ink jet printhead subunits to make a pagewidth thermal ink jet print bar, there are significant differences in the print bar architectures, depending upon which printhead subunit architecture is used. Figures 3A and 3B show staggered subunit pagewidth print bars using sideshooter printheads, while Figure 6 shows a staggered subunit pagewidth print bar using roofshooter printheads. The pagewidth printheads of Figures 3A and 3B use the staggered offset configuration of sideshooter printhead subunit, while the pagewidth printhead of Figure 5 uses pagewidth printhead subunits in an end-to-end abutment arrangement.

The pagewidth print bar of Figure 6 uses alternating staggered roofshooter printhead subunits in which each subunit has two arrays of staggered nozzles, one on each side of the ink reservoir or feed slot in the heater plate, although a single row of nozzles could be used as shown in Figure 2 and disclosed in U.S. 4,789,425 to Drake et al. The use of two staggered rows of roofshooter printhead subunits avoids the technical issues associated with abutting collinear subunits as shown in Figure 5, while preserving the adjacent nozzle distance across the pagewidth printhead. However, the array of subunits can also consist of a single row of abutted subunits, such as those described in U.S. 4,985,710 to Drake et al. While technically more difficult because of the required precision dicing, such a collinear array has the advantage of consuming less space in the Y or paper path direction. As discussed above with reference to Figure 2, the roofshooter printhead subunits are fed with ink via

a reservoir or slot in the print bar mounting substrate. The seal between the heater plate of the subunit and the substrate can simply be a printhead bonding adhesive normally used to attach printhead subunits to a substrate. This seal has no precision tolerances and uses commercial techniques and materials.

In the process of precision placement of the printhead subunits, there is a significant difference in the roofshooter and sideshooter pagewidth print bar architectures. Close tolerances are critical in the X and Y axis for spot placement. The X and Y axis are in the plane of the printhead for roofshooters as seen in Figure 6, while, for the sideshooter, the X and Z axis are in the plane of the printhead but the Y axis is out of the plane of the printhead. The importance of this is twofold. First, roofshooter printheads can be aligned without the significant issues of silicon chip thickness variation or warpage of the structural substrate bar on which they are attached. These two dimensional variations effect the Z axis dimension which is much less critical for spot placement. For the sideshooter configuration, these two issues significantly effect the critical Y axis dimension, introducing adjacent pixel spot placement errors. For example, because of printhead subunit thickness variation from wafer to wafer (normally  $\pm 13$  micrometers), sideshooter printhead subunits for a given print bar may need to be taken from the same wafer to ensure thickness uniformity, while roofshooter die subunits can be taken from any wafer because the thickness variation occurs in the non-critical Z axis. Secondly, aligning printhead subunits in their natural plane, that is the plane of the wafer, as is done for roofshooter printheads, is already commercially done for a number full width arrays of silicon transducer technologies, therefore off-the-shelf commercial equipment exists for such alignment.

Another advantage of the pagewidth thermal ink jet roofshooter print bar architecture lies in its stability to thermal excursions. Figure 7 shows the problem for a pagewidth sideshooter architecture. Because the side of the bar with the bonded printheads will be at a higher temperature than the opposite side, thermal expansion of the warmer side will cause a bow in the bar. Figure 7 gives a mechanical analysis of this situation. Assuming representative material constraints and dimensions, there is a bow in an eleven inch print bar corresponding to twelve micrometers for each degree centigrade gradient from the top to the bottom of the structural bar, even for an extremely low expansion material such as graphite. Furthermore, this bow affects spot placement in the critical Y direction for a sideshooter. As can be seen from Figure 7, the critical dimension is the bar thickness t,



which has a cubed relationship relative to the print bar stiffness (that is, warp resistance). Force  $F = \alpha \Delta T A E$  where  $\alpha$  = the constant of thermal expansion,  $A$  = cross-sectional area,  $\Delta T$  = the thermal gradient,  $E$  = the modulus of elasticity,  $t$  = the bar thickness. Bending moment  $M = Ft/2$ , and radius of curvature  $R = EI/M$ , where  $I$  is the moment of inertia which equals thickness of the structural bar  $t \times$  the height cubed  $\div 12$ . If, for example, the structural bar is graphite for a  $\Delta T = 1^\circ\text{C}$ , thickness = .25 inches and the depth = 2 inches, the constant of thermal expansion for graphite is equal to 2.5 cm/cm/ $^\circ\text{C}$ . The modulus of elasticity for graphite is equal to  $1.5 \times 10^6$  psi. The force equals 2.5 pounds, the radius of curvature = 24,000 inches and this results in a bow or change in the Y direction of 12 micrometers per degree centigrade.

For the pagewidth printhead using roofshooter printhead subunits shown in Figure 6, it can be seen that the direction of thermally induced structural bar warp would be in the less critical Z axis direction and that the critical dimension T can be made very large. As an example of typical values, T might be .25 inches for a sideshooter and might be 2.5 inches for a roofshooter print bar. One reason the T dimension can be large for the roofshooter print bar is because it does not consume paper path space. The effect on the mechanical stability of the print bars would seem to be 1,000 times more rigid than the sideshooter print bar. In terms of ink distribution systems, the pagewidth roofshooter print bar does not require a dedicated ink manifold, since it can feed ink from a reservoir internal of the print bar substrate up through the slot in the silicon heater plate. This not only saves the cost of a manifold and the critical step of printhead to manifold ink sealing, but also allows the printhead and print bar substrate to transfer their heat to the ink which then gets expelled during printing. Thus, the pagewidth roofshooter print bar would have an advantage with respect to thermal management. Also, a pagewidth thermal ink jet print bar using roofshooter style printhead subunits enables the use of a print bar substrate having dimensions to minimize the Y axis dimensional tolerances and to provide a larger dimension in the Z axis which confers stiffness and a warp resistance to the print bar. A print bar substrate for a roofshooter pagewidth printhead may incorporate the ink distribution system internally, thus eliminating additional ink distribution components. In addition, this design is thermally advantaged in that the heat from the silicon subunits is transferred to the structural substrate and the ink, where it can more readily leave the ink printing system.

In multi-color ink jet printing systems, several pagewidth printheads must be used, one for each color. Generally, four printheads are used, one for

black and one each for magenta, yellow and cyan. To prevent the ink from wicking into the recording medium, usually paper, it is important to minimize the area of the printing zone so that the ink can quickly be dried. A front view of a multi-colored thermal ink jet printhead is shown in Figure 8 utilizing roofshooter-type pagewidth printheads of the type shown in Figure 6. Because the printhead subunits are bonded to the edge of the structural bar facing the Z direction, the pagewidth printheads may be stacked one on top of the other spaced only by the flexible electrodes, which have a thickness of about 0.1 to 0.2 cm, thus presenting a printing area defined by the length of the pagewidth printhead and the distance defined by the thickness of four structural bars shown in Figure 8 as L and  $P_1$ , respectively. In the preferred embodiment, L is between 8.5 inches (21.6 cm) and 11 inches (28 cm) and W (Figure 6) is between 0.25 inches (0.64 cm) and 0.5 inches (1.3 cm), so that  $P_1$  is between about 1.5 inches (3.8 cm) to 2.25 inches (5.7 cm). A similar front view of a multi-color pagewidth printer using sideshooter printhead subunits is shown in Figure 9. Each of the pagewidth printheads uses the end-to-end abutment of printhead subunits, as shown in Figure 5. The printing area is defined by the length L of the printing region of the pagewidth printheads and the height of four printheads with ink supplying manifolds 37 for each of the printheads so that the distance  $P_2$  of the stacked pagewidth printheads is about 3 inches (7.6 cm) to 4 inches (10 cm) which is greater than that of the roofshooter type print bar. Any Y distance for a printing zone greater than 2.5 inches for the printing zone is considered detrimental for it permits the wet ink too much time to wick into the paper before a means for drying can be applied, thereby allowing the paper to cockle or wrinkle. Though a sideshooter type pagewidth printhead using abutted subunits as shown in Figure 5 was used in Figure 9, substantially the same or larger printing zone would be required for a multicolor ink jet printer using a plurality of the pagewidth printheads depicted in Figures 3A and 3B. Therefore, the same unsatisfactory color printing would be achieved as with the printhead configuration shown in Figure 9.

The printhead illustrated in Figure 6 and described above has a minimum dimension in the direction of the movement of the recording medium relative to the printhead. In addition, it has a comparatively large dimension in the direction perpendicular to both the recording medium and printhead in order to confer stiffness and warp resistance to the printhead. The print bar internally incorporates the ink distribution system, thereby eliminating additional ink distribution components and resulting in the ability to more closely space

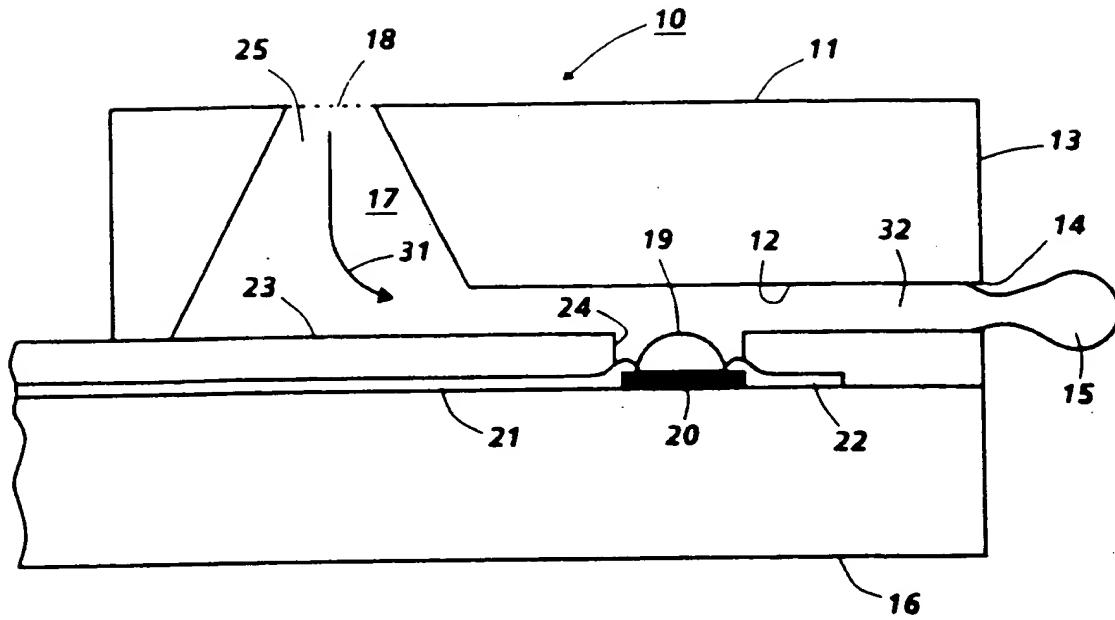
pagewidth printheads for multi-color printing.

### Claims

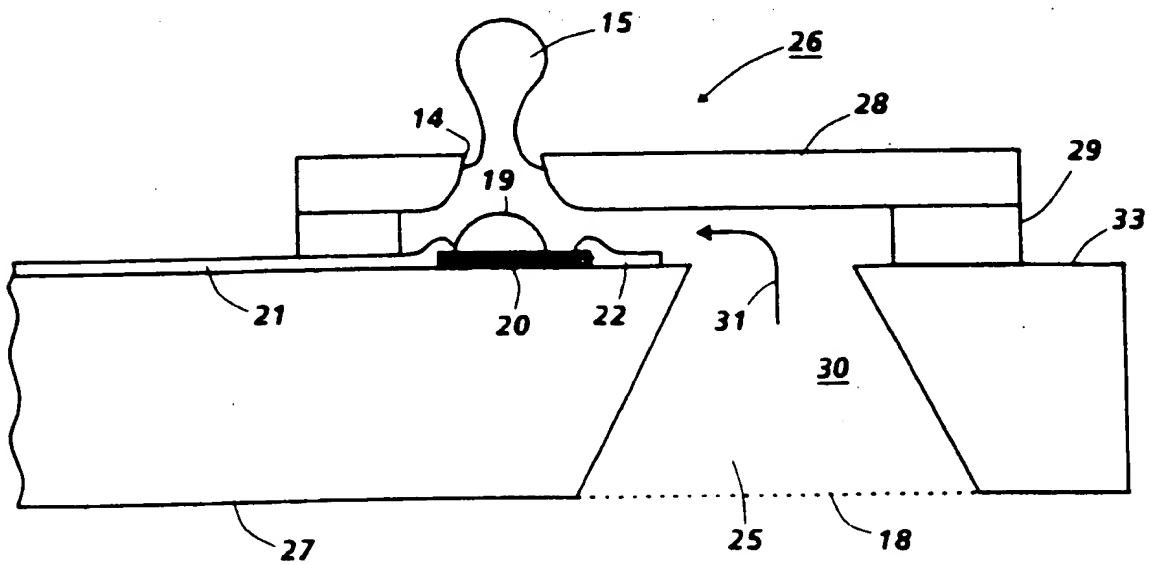
1. A pagewidth, thermal ink jet printhead for use in an ink jet printer, the printhead comprising:
  - a structural bar (62) having an edge surface (67) which confronts the recording medium path when the bar is mounted in the printer;
  - a passageway (64) provided within the bar;
  - a plurality of openings (65) penetrating the said edge surface and communicating with the passageway;
  - a plurality of roofshooter-type printhead subunits (26A) mounted on the bar edge surface, each subunit having an ink inlet (25) aligned with a respective one of the openings in said bar edge surface, an array of droplet emitting nozzles (14), and a plurality of heating elements (20), each of which is aligned with a respective one of the subunit nozzles for ejection of ink droplets in a direction normal to the heating elements and to the said edge surface, the nozzles of the plurality of subunits defining a printing zone having the length (L) of at least the width of a page;
  - means for providing ink to the bar passageway from an ink supply; and
  - means (46) for selectively applying electrical signals to the heating elements of the subunits, the thickness (T) of the structural bar being sufficient to prevent the bar warping as a result of the operating temperature of the pagewidth printhead.
2. A pagewidth printhead as claimed in claim 1, wherein the roofshooter printhead subunits are mounted on the edge surface of the bar in two rows in a staggered arrangement.
3. A pagewidth printhead as claimed in claim 1 or claim 2, wherein each printhead subunit has two rows of nozzles.
4. A pagewidth printhead as claimed in claim 1, wherein the roofshooter printhead subunits are mounted on the edge surface of the bar in a single, abutted collinear row of subunits.
5. A pagewidth printhead as claimed in any one of the preceding claims, wherein the structural bar comprises a main part with a groove in a surface thereof and a cover (63) mounted on the said surface of said main part and over the groove therein to form the passageway in said bar, the plurality of openings being in said cover, so that said edge surface of the bar

whereon the subunits are mounted is the outer surface of the cover.

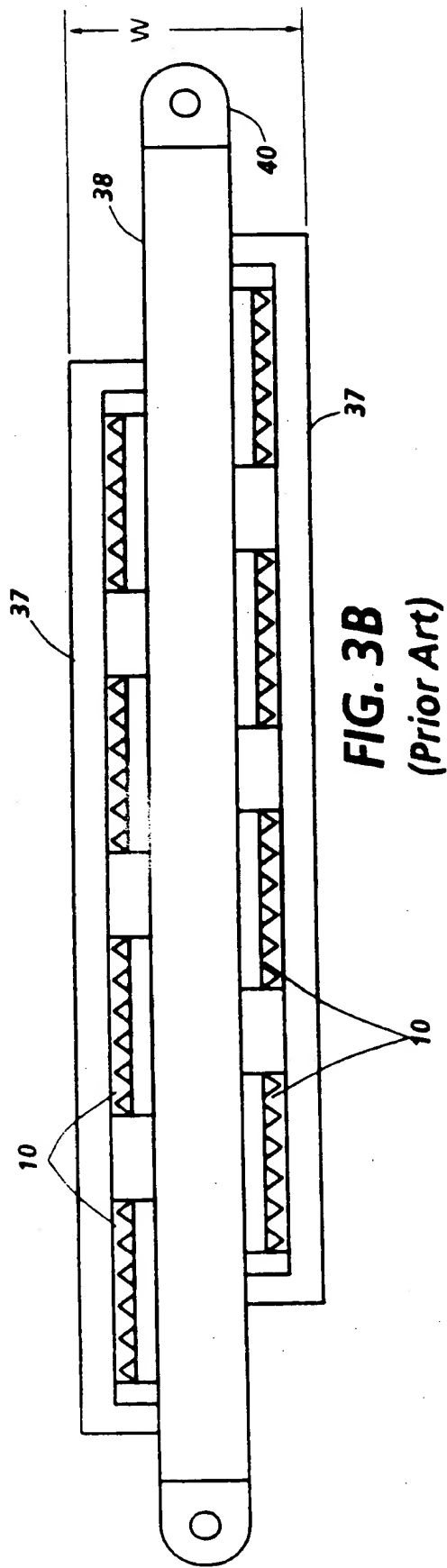
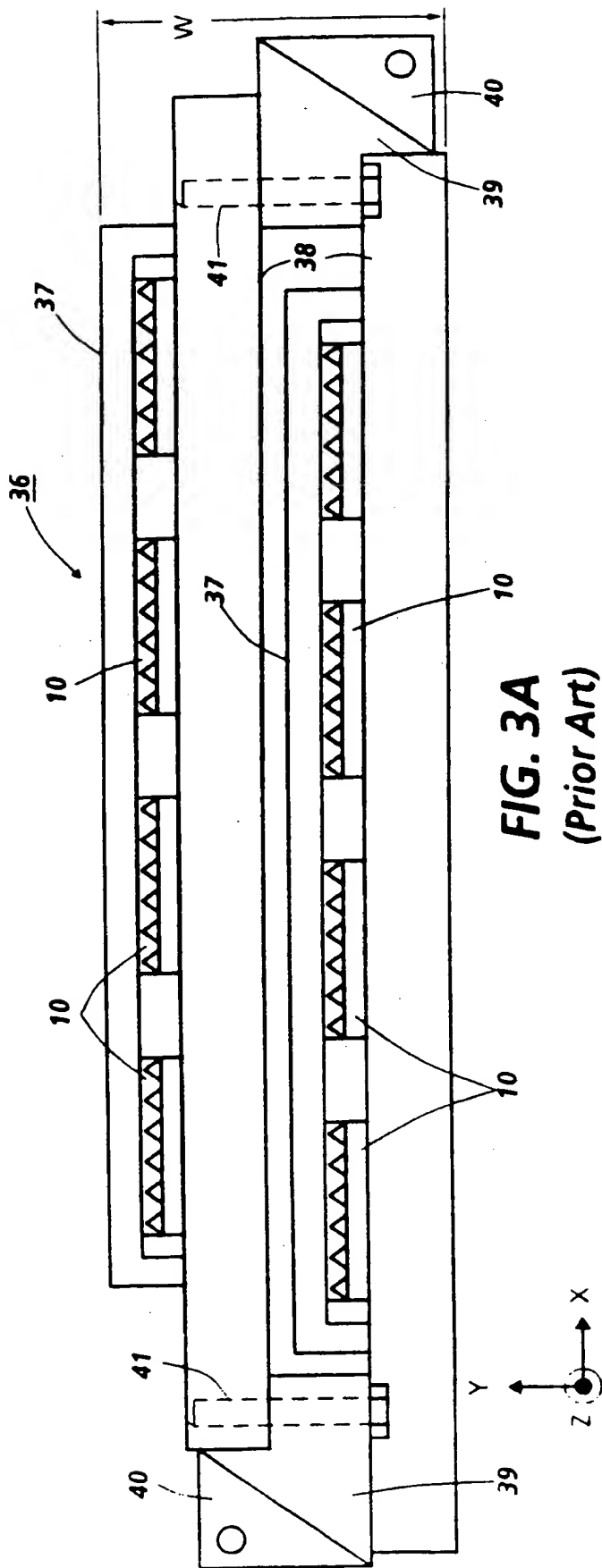
6. A multicolor printer comprising a plurality of pagewidth printheads each as claimed in any one of the preceding claims, the printheads being stacked with their respective subunits confronting the printing zone of the printer, and a different colored ink supply for each pagewidth printhead.

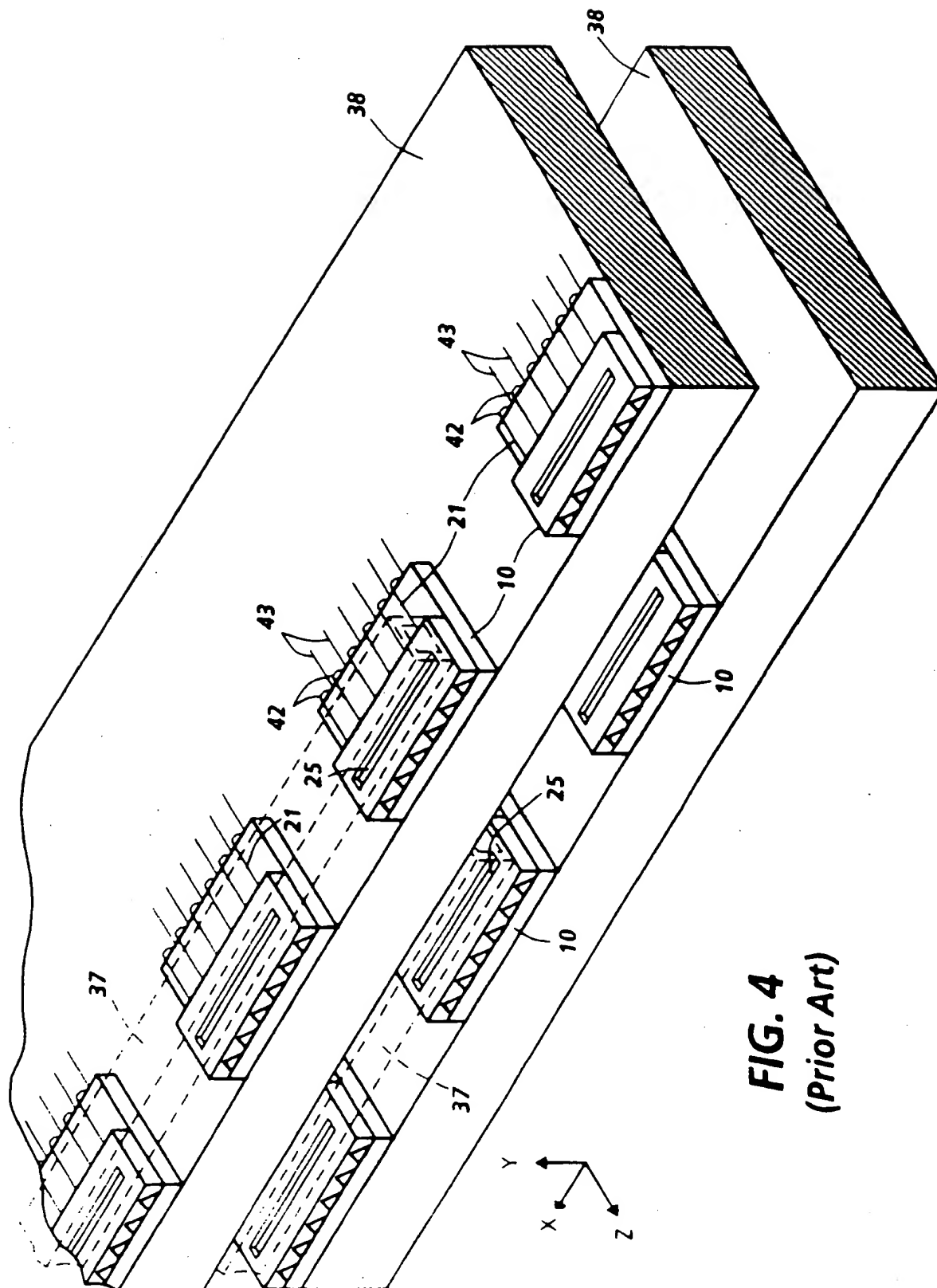


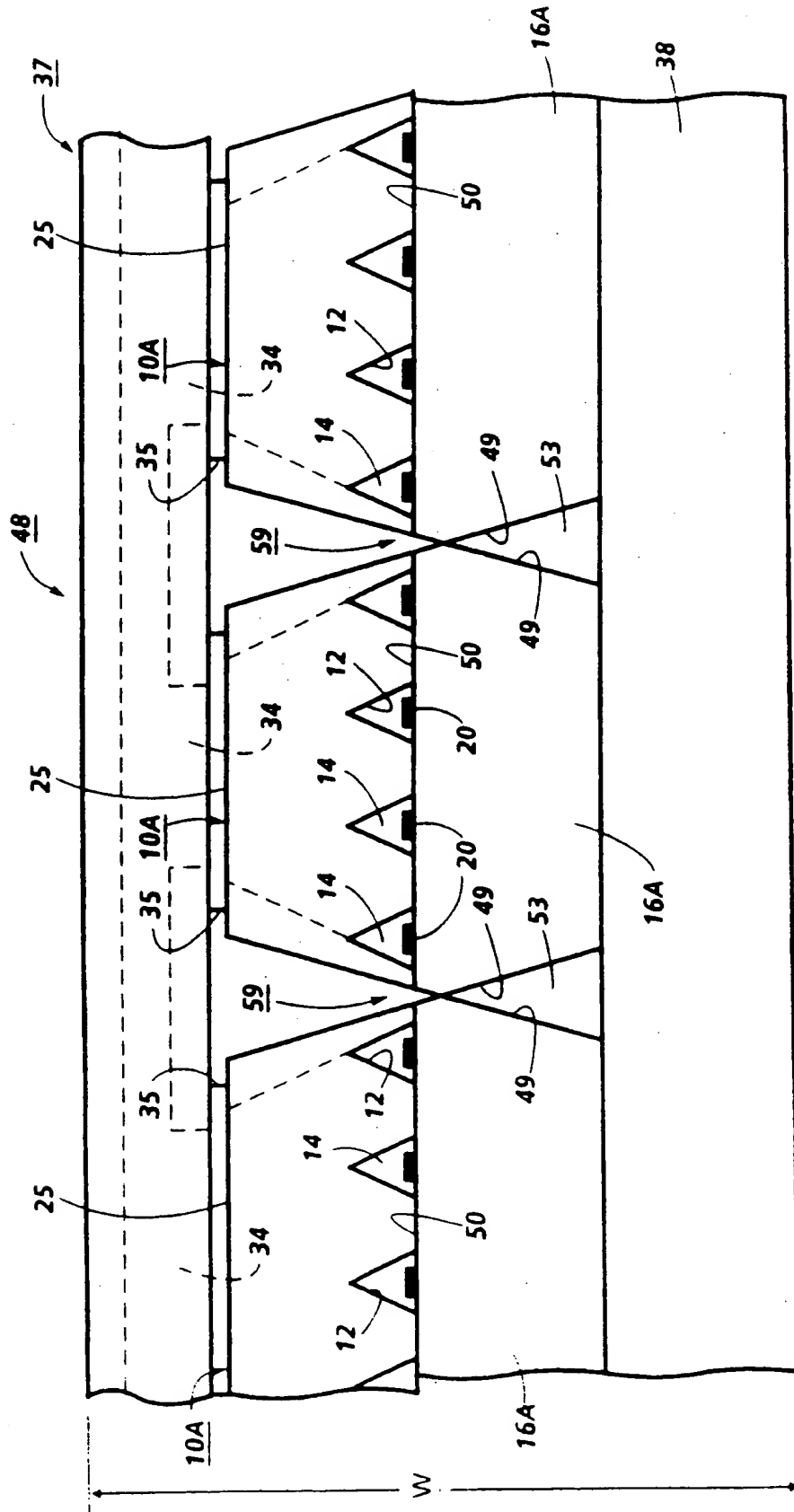
**FIG. 1**  
**(Prior Art)**



**FIG. 2**  
**(Prior Art)**







**FIG. 5**  
(Prior Art)

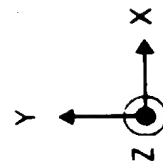
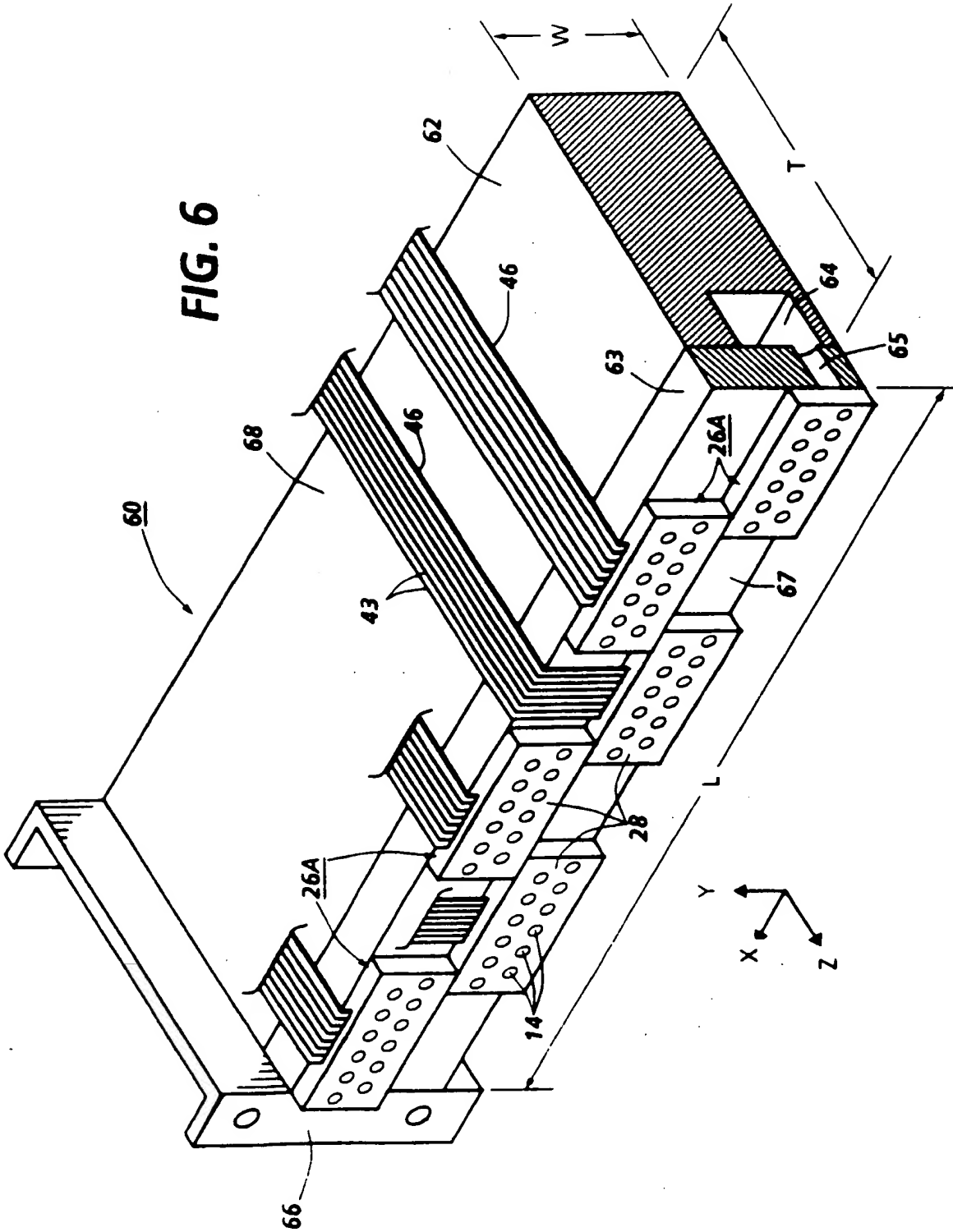
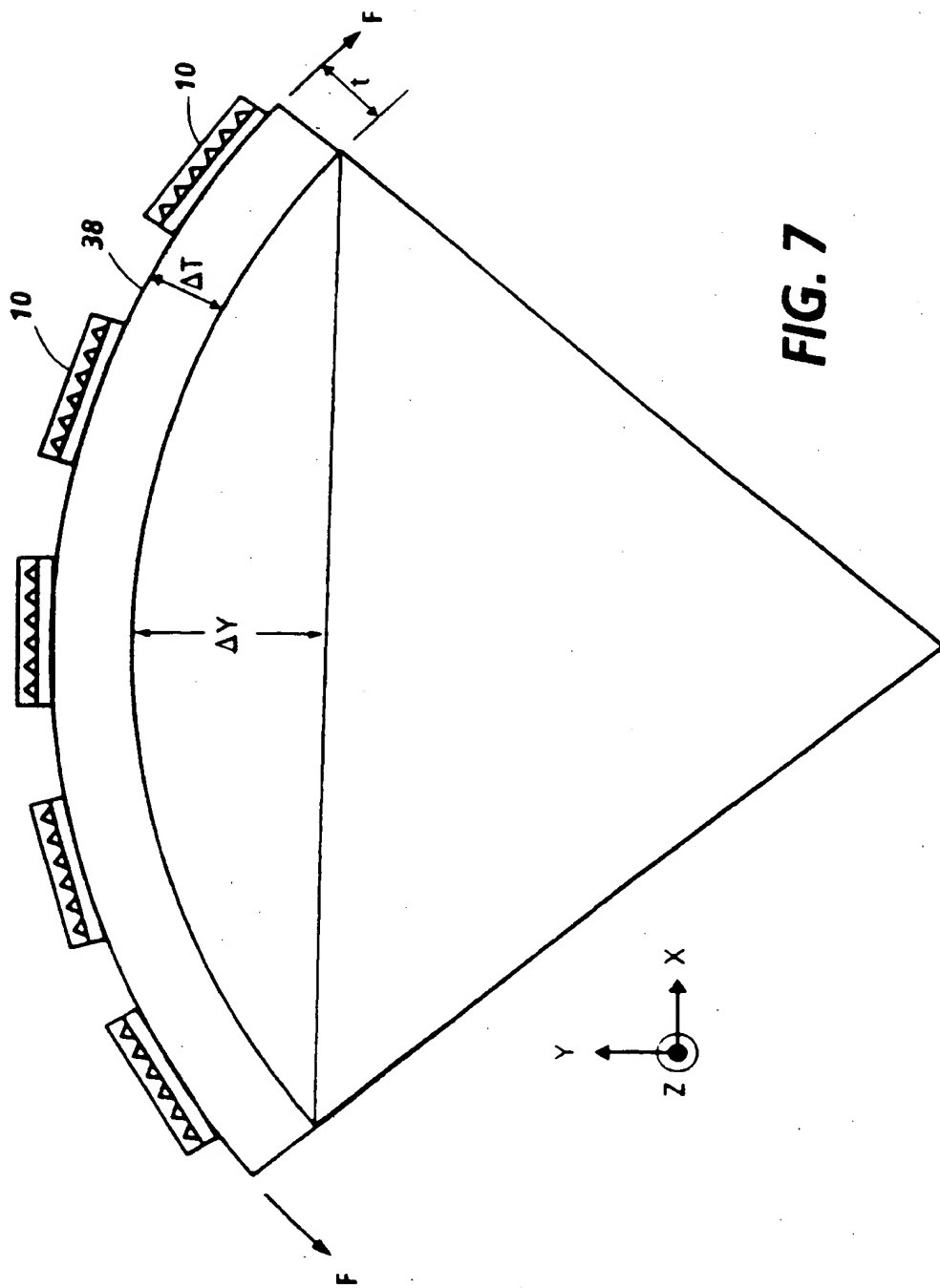
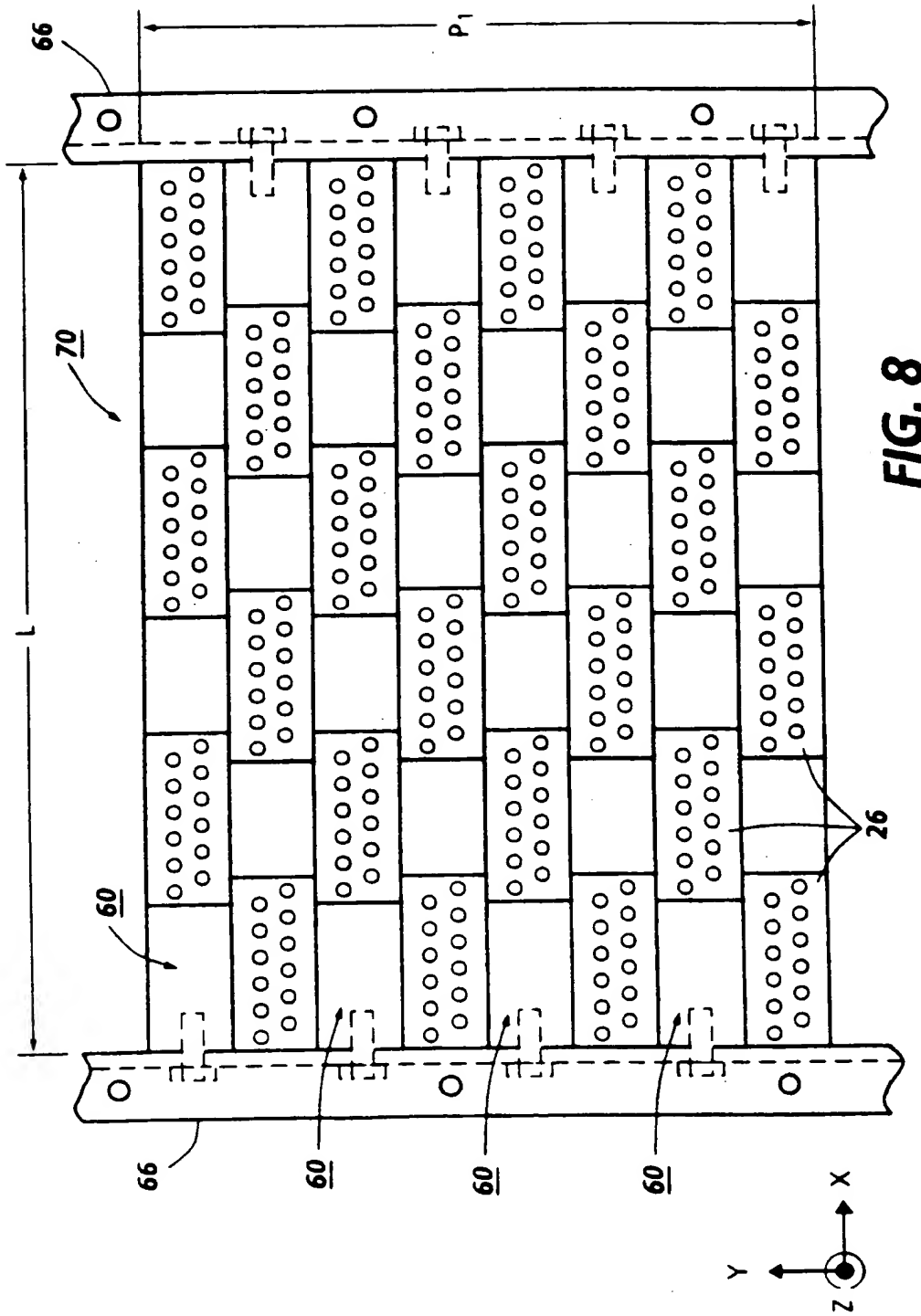


FIG. 6









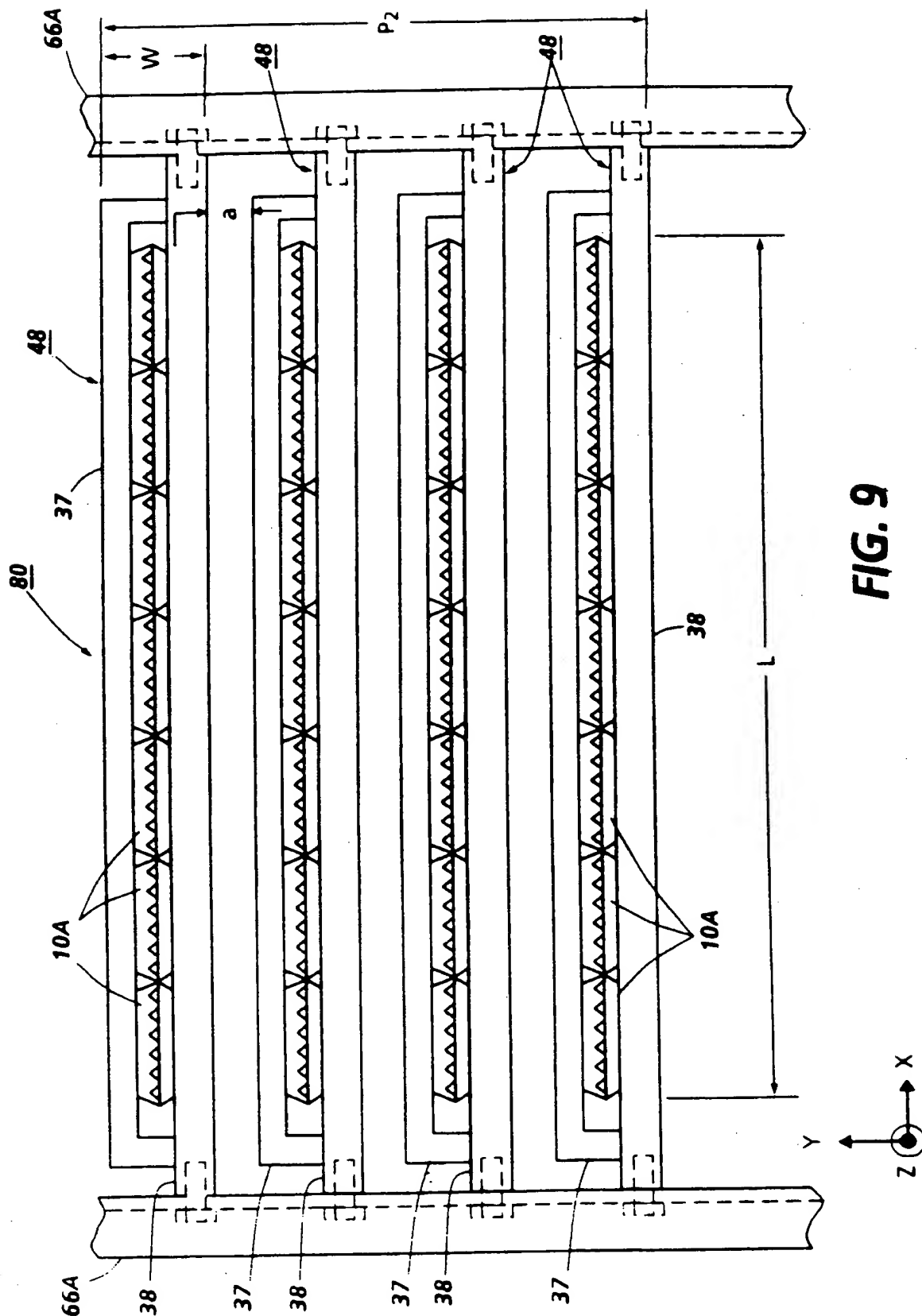


FIG. 9

(19)



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**20.01.93 Bulletin 93/03**(71) Applicant: **XEROX CORPORATION**

**Xerox Square  
Rochester New York 14644(US)**

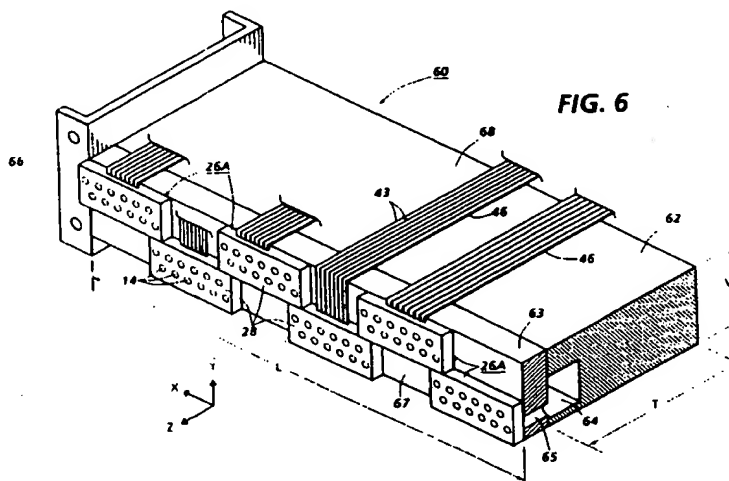
(72) Inventor: **Drake, Donald J.  
480 French Road  
Rochester, New York, 14618(US)**

(74) Representative: **Hill, Cecilia Ann et al  
Rank Xerox Patent Department Albion  
House, 55 New Oxford Street  
London WC1A 1BS(GB)**

(54) **Pagewidth thermal ink jet printhead.**

(57) A pagewidth thermal ink jet printhead for an ink jet printer is disclosed. The printhead is of the type assembled from fully functional roofshooter type printhead subunits (26A) fixedly mounted on the surface of one side (67) of a structural bar (62). A passageway (64) is formed adjacent the bar side surface containing the printhead subunits with openings (65) provided between the passageway and the ink inlets of the printhead subunits, mounted thereon so that ink supplied to the passageway in the bar will

maintain the individual subunits full of ink. The size of the printing zone for color printing is minimized because the roofshooter printhead subunits are mounted on one edge of the structural bar and may be stacked one on top of the other without need to provide space for the printhead subunits and/or ink supply lines. In addition, the structural bar thickness (T) enables the bar to be massive enough to prevent warping because of printhead operating temperatures.

**FIG. 6****EP 0 512 799 A3**



European Patent  
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## EUROPEAN SEARCH REPORT

Application Number

EP 92 30 4052

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 289 (M-728)(3136) 8 August 1988 & JP-A-63 064 757 ( H. KOMAI ) 23 March 1988 * abstract * ---	1-2, 4-5	B41J2/155
A	EP-A-0 340 960 (AM INTERNATIONAL INC.) * the whole document * ---	3-4	
A	US-A-4 536 097 (K. NILSSON) * column 5, line 39 - line 45; figure 8 * -----	6	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B41J
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 17 NOVEMBER 1992	Examiner G. v/d MEERSCHAUT
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document			